phocos

FC20, FC40

Hybrid Solar Power Fuel Cell Unit

User Manual

2007-08-16

Preface

This user manual informs about the appropriate operation of the hybrid solar power fuel cell unit FC20/FC40. The fuel cell unit serves for charging 12 V / 24 V lead accumulators.

The user manual has to be stored.

It is not allowed to copy or to manifold texts, plans and tables or to make them available to third persons without our formal approval.

We point to the fact that this manual is not part of any existing previous agreement or consent, or any part of a legal relationship.

All obligations arise from the sales contract, which also exclusively contains the warranty regulation. The user manual does not affect the stipulations.

The documentations and user manuals of the suppliers of the purchased parts and components used are also valid in the context of this manufacturer's user manual.

In addition to the user manual, all general legal and other binding rules for accident prevention and environmental protection have to be considered and applied.

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1 Introduction

Before using the device or the installation connected with it for the first time, it must be categorically ensured that this user manual has been completely read in order to guarantee the safety of the operator and to avoid possible damages to the fuel cell unit.

The present user manual is aimed to support a better knowledge of the fuel cell unit and its use according to the appropriate working conditions.

Before putting the fuel cell unit into operation, the operating staff must become acquainted with all components and their functions. In particular, the topic of safety must be taken into account.

The present user manual contains important indications as to the appropriate and economical use of the fuel cell unit. The observance of these instructions helps to avoid risks, to reduce costs due to repair and downtimes, and to extend the service life of the device.

In the individual chapters, on the margin of the text occasionally symbols are printed indicating the function of the respective paragraph. These indications are important for the operation or the maintenance, or they indicate important descriptions or remarks, respectively:

Danger

All paragraphs in the user manual that contain indications to possible endangerments are marked with the alongside symbol.

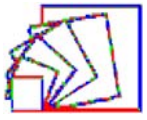
Non-observance might implicate severe injuries! The instructions have to be strictly adhered to.

Attention

All paragraphs marked with this symbol provide indications for the avoidance of damages to the installation.

Hint

Paragraphs with this symbol give important hints for effective work.



The working steps that are described in logical order adjacent to this symbol specify the most ergonomic way of operation.

2 Identification

2.1 Product brand and type designation

Phocos® FC20/FC40

2.2 Product version / release no. (software) / document issue

Product version:	FC20/FC40
Software version:	V01.00 Build109
Issue:	10/2006

3 Product Description

3.1 General functions, and areas of application; appropriate use

The fuel cell unit FC20/FC40 is assigned for charging lead accumulators with rated voltages of 12 V / 24 V in the allowed temperature range.

It must be considered that the user or the manufacturer must input the application-related voltage levels of the automatic charge control before putting the fuel cell unit into operation.

On delivery, factory settings are parameterised ensuring an automatic cyclic charging mode.

- Accumulator type: Lead accumulator
- Final charging voltage: 14.4 V / +25 °C
- Switch-on voltage: 11.5 V
- Temperature correction value for accumulator: 34.8 mV/K
- Stack voltage: 1.8 V / stack

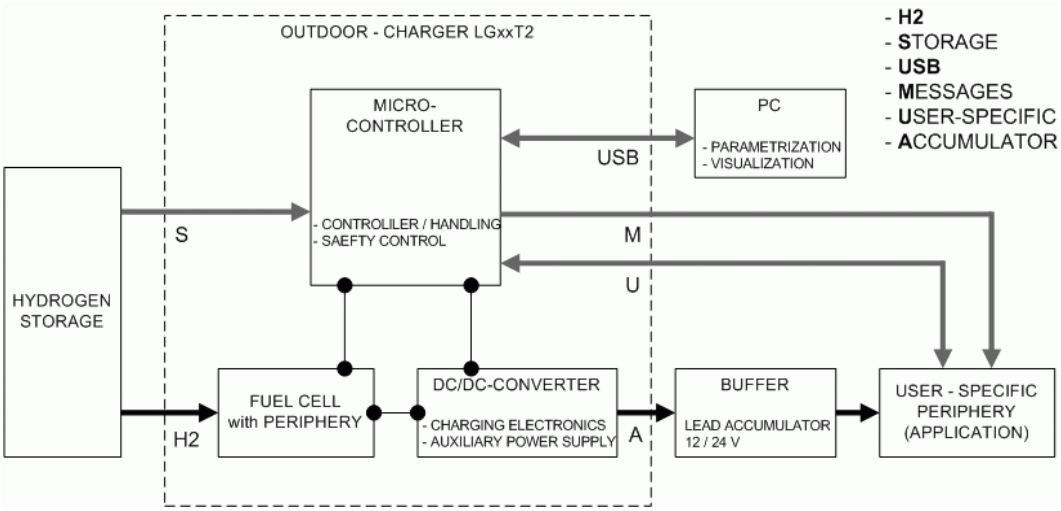


Fig. 1: Basic circuit diagram

3.2 Technical information and data

Performance data:

Power (FC20 | FC40)	20 W | 40 W
Charging voltage (12 V | 24 V)	10.5…14,7 V | 21,0…29,4 V
Maximum charging current (FC20 | FC40)	2,0 A / 1,0 A | 4,0 A / 2,0 A
Hydrogen consumption (approx. for the above given power) (FC20 | FC40)	20 Nl / h | 40 Nl / h
Cooling	Water
Permitted accumulators	Lead accumulator/lead-gel accumulator 12 V / 24 V

Interfaces / Inputs / Outputs:

Data exchange	USB interface GSM module (optional)
Analog inputs	2 x 0..10 V (in connection with GSM option)
Digital inputs	2 x 0..5 V (in connection with GSM option)
Digital outputs	2 x 0..5 V (in connection with GSM option)
Signal output	3 x 0..5 V

Gas supply:

Hydrogen	Purity 3.0 (99.9%) or better
CO content	< 20 ppm
Operation pressure hydrogen	Minimum 1 bar – maximum 10 bar
Connection	Self-sealing snap closing
Process air	Clean ambient air, good aeration

Environmental conditions

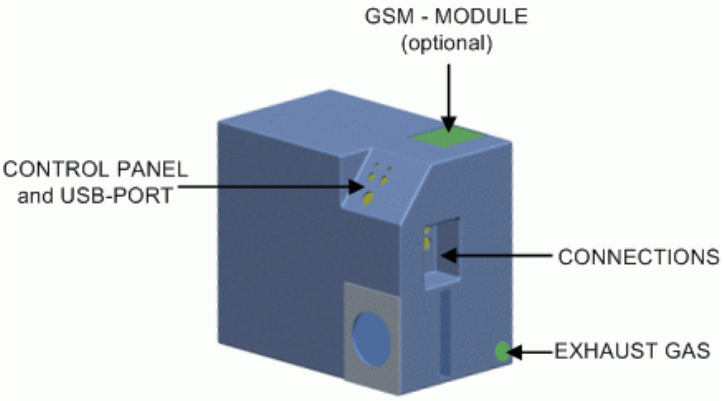
Ambient temperature range	-25…+50 °C (if the device is operationally connected)
Storage temperature	Minimum 5°C (system temperature)

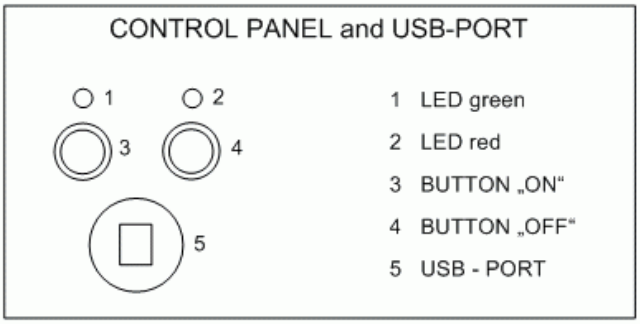
Degree of protection	IP 54
Pollutants	The ambient air must not contain increased concentrations of sulphur compounds, carbon monoxide, ammonia, chlorine compounds, solvents and dust.

Casing

Dimensions	415 mm x 335 mm x 235 mm
Material	Plastic material
Mass	About 9.5 kg

Connections





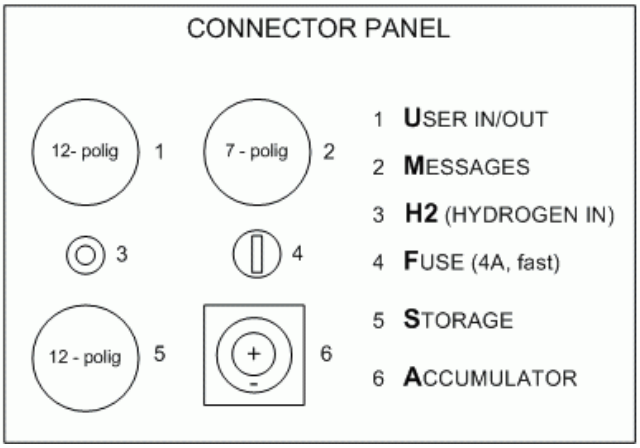


Fig. 2: Situation of the connections and the control elements

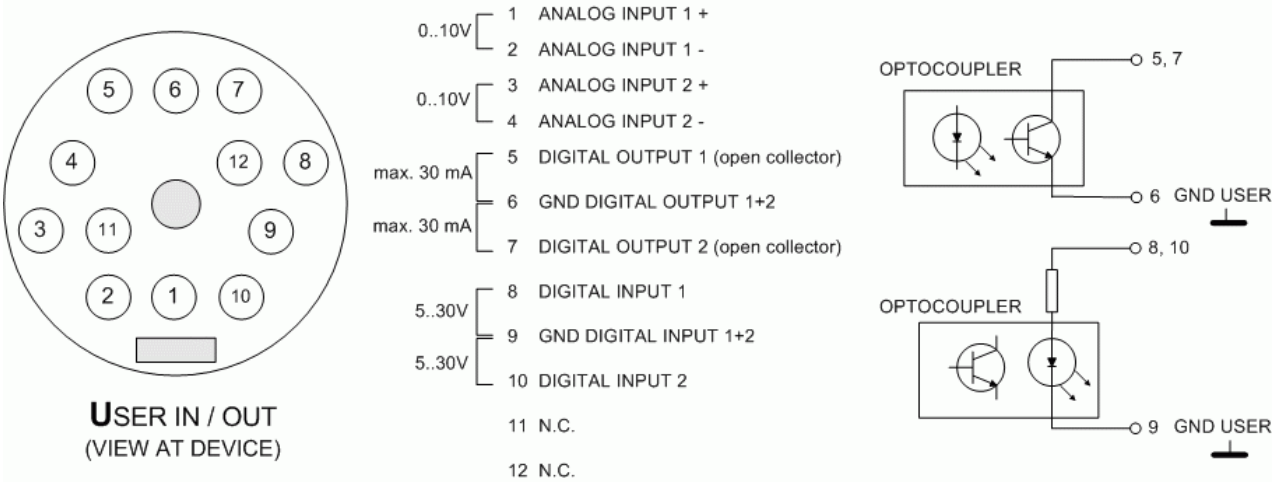


Fig. 3: Disposable connections

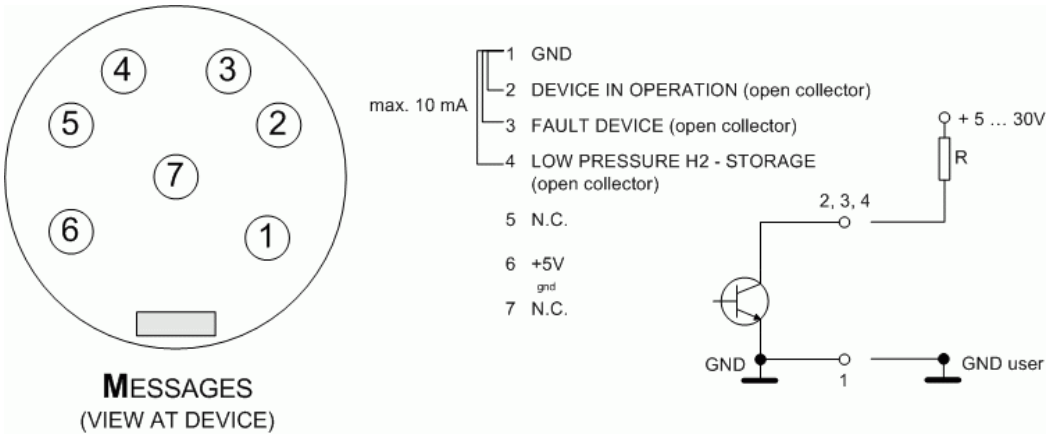


Fig. 4: Connection signalling

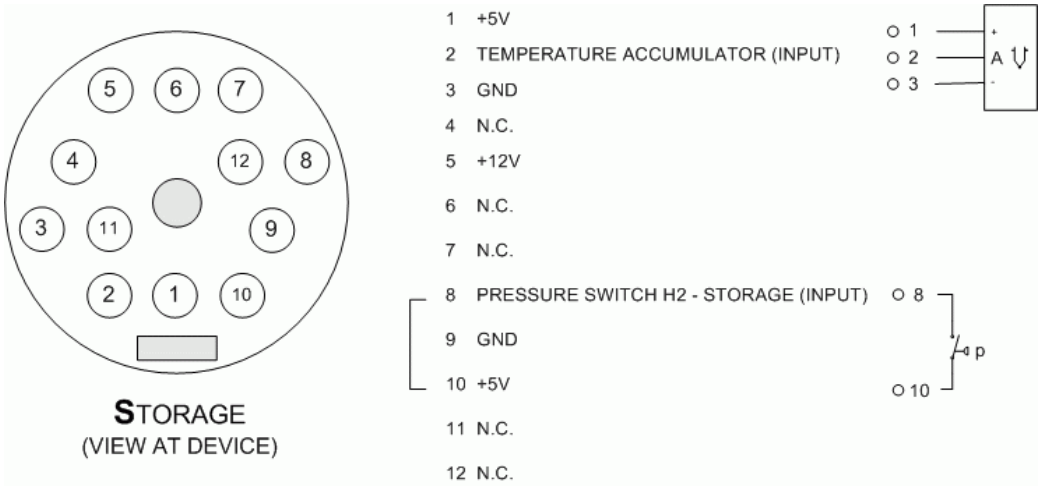


Fig. 5: Connection external hydrogen storage

Scope of supply

- Hybrid solar power fuel cell unit FC20/FC40
- Plug for connection of accumulator
- Special connector for hydrogen connection
- PC software for Windows (2000, XP) for visualisation and parameterisation
- User manual

Optionally

- Temperature sensor for accumulator
- Internal GSM module for data transfer
- IN / OUT interface (2 x digital out, 2 x digital in, 2 x analog in); comprised in GSM option
- Implementation of user-specific program tools for user-IN / OUT
- Pressure control fittings for gas cylinders 200 bar, on 0 – 10 bar, and connecting hose 2.5 m
- Solar accumulator 12V / 6.6 Ah (other capacities on request)
- Steel casing (IP 64)
- Putting into operation at customer's premises

3.3 Emissions and environmental compatibility

During the operation of the fuel cell unitFC20/FC40, low amounts of hydrogen are emitted (flushing of the anode). Furthermore, during power generation, water (water vapour) is generated escaping together with the hydrogen on the bottom part of the device.

3.4 Safety information

The fuel cell unit was developed and produced according to state-of-the-art technology, and it was subject to a safety inspection before delivery.

However, faulty operation or misuse can cause danger for persons and for the fuel cell unit.

Every person involved in setting up, operating or maintaining the fuel cell unit must:

1. read this user manual and adhere strictly to its instructions;
2. be trained and appropriately instructed for his/her activity.

3.4.1 Safety measures on the installation location

Danger

When hydrogen is used as energy source, fire and explosion hazards are generally increased

The use of open fire, as well as smoking is strictly forbidden in this area.

The rooms in which the fuel cell unit will be operated must dispose of the following:

- Local removal by suction for hydrogen on the installation location, or
- a room air suction or aerating installation on the room ceiling enabling safe exhausting of the rising hydrogen out of the room.

The installation location has to be chosen in a way that product water escaping from the bottom of the fuel cell unit in the course of operation cannot cause damages or endangerments.

Attention

No electrical or electronic components, or other components sensitive to water are permitted below the fuel cell unit.

3.4.2 Remaining endangerments

The described product complies with the state-of-the-art and the generally accepted safety-related rules. However, the occurrence of dangers cannot be excluded.

The remaining endangerments in connection with the use of the device are due to:

- The use of hydrogen accumulators and the associated fittings including the connecting pipes to the device.
- The use of lead accumulators and their possible improper use.

In this context, the regulations applying to these components have to be considered and observed according to the installation location.

3.4.3 Qualification of the operating staff

Only persons with technical (preferably electrotechnical) training who are able to realise the connections in a professional manner are allowed to put the fuel cell unit into operation and to connect it.

For the operation of the PC user interface belonging to the scope of supply, basic knowledge on the current WINDOWS system software is required. The respective details can be found in the attached detailed program description.

4 Preparation for the Use of the Product

4.1 Transport

For the transport of the device, the following must be taken into account:

- Transport exclusively in upright position
- Temperature range during transport: +5..+50 °C
- Soil- and dust-resisting packaging, which is, however, permeable to air
- Vibrations, strong shocks, impacts and blows have to be avoided

4.2 Packaging

Generally, for the transport or the shipment of the device, respectively, packaging that is suitable for the destination and for the object, and that is environmental-friendly has to be used.

As the device itself has a degree of protection of IP54, a packaging type has to be selected for transport that prevents penetration of water, soil and dust. The use of conventional dehumidifiers is recommended.

4.3 Storage

It is only allowed to store the device after it has passed through a complete phase of cooling down. This phase of cooling down is realised in the automatic charging operation mode after the final charging voltage has been reached, or after a shut down by the device due to the characteristics of the system. Additionally, the following has to be considered:

- Storage exclusively in upright position
- Temperature range during storage: +5..+50 °C
- Soil- and dust-resisting packaging, which is, however, permeable to air

4.4 Putting into operation

Before putting the device into operation, the following conditions have to be ensured and to be checked:

- Professional installation and layout of all required connecting lines and conduits (electricity and media) and their correct connection to the fuel cell unit and the other system components, respectively.
- The availability and correct functioning of the room aeration for fresh air supply, and for the exhaustion of the hydrogen escaping due to normal operation mode.
- The minimum temperature of the device is +5° C.
- The indications and instructions of this user manual must be known.

4.4.1 Choice of the accumulator

The fuel cell unit is designed for cyclic operation. That means that the power supply system must be dimensioned in a way that the average power taken from the accumulator is less than the power supplied by the fuel cell unit. Special attention must be paid to the capacity of the chosen accumulator. In dependence of the energy demand of the installation to be supplied with power, the capacity of the accumulator determines the frequency and the duration of the charging cycles. If the fuel cell unit is used in areas where outside temperatures only slightly above or even below 0 °C can be expected, the duration of the charging cycles should be optimised in order to reach high energy efficiency. During their operation, the fuel cells provide enough heat to ensure optimum temperature conditions in the interior of the device. However, in case of the above-mentioned low outside temperatures, this requires several hours of operation of the device. In order to keep the heating period as short as possible, a part of the generated electrical energy is temporarily used for an internal heating element. The corresponding amount of energy will be derived from its normal purpose – the charging of the accumulator. In this case, full cooling down due to long charging pauses should be avoided in order to avoid full-length heating periods. Conditions for which charging pauses in case of temperatures distinctly below 0 °C do not take longer than 24 hours can be considered as energetically favourable.

For the determination of the optimum accumulator capacity, the essential influencing factors are the temperatures to be expected, and the average power consumption of the application. Appropriate recommendations will be provided in the context of the initial putting into operation, or on request.

4.4.2 Connection of the hydrogen accumulator

For hydrogen supply, the parameters mentioned above are relevant. For a safe connection or exchange, respectively, of the pressure vessel the following sequence has to be followed:

1. Switch-off the fuel cell unit FC20/FC40 (red key).
2. Pull the accumulator plug. The power supply by the fuel cell unit will be interrupted.
3. Close the hydrogen cylinder.
4. Close pressure line at the pressure control fittings of the gas cylinder.
5. Screw off fittings from the hydrogen cylinder (attention: left-handed thread!)
6. Exchange hydrogen cylinders.
7. Screw the fittings on the new cylinder.

8. (Only in case of initial putting into operation) detach snap closing of the hydrogen supply from the fuel cell unit.
9. Turn on hydrogen cylinder.
10. Open the pressure line at the pressure control fittings of the gas cylinder.
11. (Only in case of initial putting into operation) deaerate the supply pipe to the fuel cell unit (filling it with hydrogen).
12. (Only in case of initial putting into operation) connect the snap closing to the fuel cell unit.
13. Connect the accumulator plug to the fuel cell unit.
14. Carry out a leak test with a gas leak spray

The hydrogen pressure on the device must be between at least 1 bar and at most 10 bars.

4.4.3 Connections on the device

Connection H2, connector panel

To this connector, the hydrogen supply line is connected. The supply of the fuel cell unit with hydrogen is necessary for its operation.

Connection A (accumulator), connector panel

This connector is used for the connection of the lead accumulator to be charged. A connected accumulator is necessary for the operation of the fuel cell unit (pin as-

signment: +/1+ | -/1-), whereas the accumulator voltage must be within the limits of the specified range of the charging voltage.

USB connection, connector panel

The USB connector connects the fuel cell unit with a computer. The visualisation and parameterisation software contained in the scope of supply enables easy access to all functions of the fuel cell unit. Besides the possibilities of parameterising, data acquisition, data storage, and visualisation, complete access to the optional GSM module is assured (see 6.4.7).

Connection U (user-specific connection), connector panel

If a GSM module (optional) is available, the user can use the connector U. Besides 2 analog inputs it has 2 disposable digital inputs and 2 disposable digital outputs (pin assignment: see 3.2). The inputs and outputs can be logically connected with each other. As a result of these logical connections, respective messages can be transmitted by SMS and/or e-mail. For example, the level of a digital output can change and/or an SMS and/or e-mail can be transmitted when a threshold value has been exceeded for an analog output. Inversely, level changes for digital outputs can be triggered by command sequences transmitted by SMS or e-mail.

Connection M (monitored information), connector panel

By level changes of certain pins of this connector (pin assignment: see 3.2) the fuel cell unit provides external status signals. These signals can be processed by the user if required.

Connection S (H2 accumulator), connector panel

This connection (pin assignment: see 3.2) offers the opportunity for the user to provide the fuel cell unit with additional information about the connected hydrogen accumulator (optional manometric switch) or the accumulator to be charged (1 wire temperature sensor). The manometric switch can be used to signalise the state “hydrogen accumulator almost empty”. The temperature measurement on the accumulator serves for the determination of the exact final charging voltage of the accumulator (temperature-dependent adaptation of the final charging voltage).

Attention

The length of the connecting lines on the installation location must not exceed 3 m because otherwise problems with EMC (interference signals) may occur. For lengths above 3 m, screened signal cables have to be used.

The laying of the required electric cables must be carried out by a professional electrician.

4.4.4 Putting the device into operation

After it has been checked that the lead accumulator and the hydrogen supply have been connected to the device, that the accumulator voltage is within the specified range of the charging voltage, and that the hydrogen supply is ensured, the device is operational. Now, the charging process can be started manually by pressing the green key on the device, or it starts automatically when the supply voltage drops below the preset voltage level. The initialisation and all operating states will be signalised by different flashing patterns of the two LED on the device (see 5.4).

5 Operating Manual

5.1 General functional description

The fuel cell unit FC20/FC40 serves for charging 12 V / 24 V lead accumulators used for optional applications. Pure gaseous hydrogen is the primary energy source.

5.2 Operating modes

5.2.1 Accumulator voltage recognition

FC20/FC40 disposes of automatic accumulator voltage recognition. For each (new) connection of an accumulator (corresponding to "cold start" of the device) the accumulator voltage is measured several times, and the measured values are compared with the parameterised accumulator voltage. If this comparison shows a discrepancy, the device will be automatically adapted to the determined accumulator voltage, and for all relevant parameters the default values for the respective accumulator voltage will be selected. If the measured voltage is:

Attention

1. *greater than 17V for the parameterised 12 V accumulator type: → Adaptation to 24 V accumulator type*
2. *lower than 18V for the parameterised 24 V accumulator type: → Adaptation to 12 V accumulator type*

The whole process takes about 1 second, and it is accompanied by simultaneous flickering of both LED. After the adaptation of the accumulator voltage, the device will be restarted.

5.2.2 Initialisation of the FC20/FC40

After the automatic accumulator voltage recognition, the actual initialisation of the device takes place. During initialisation, several hardware tests and basic adjustments are carried out. The initialisation takes about 2 to 3 seconds, and the process is signalized by the LED (Fig. 6).

5.2.3 Initialisation of the GSM module

If the fuel cell unit is equipped with the optional GSM module, this module will be initialised, too. The initialisation takes about 10 to 15 seconds, and it is signalized by the LED (Fig. 6).

5.2.4 Charging process

The device works automatically, and the charging process starts and ends, respectively, after the adjustable minimum voltage or final charging voltage for the accumulator, respectively, are reached (Fig. 6).

Shutdown criteria

With respect to possible shutdown criteria, see description of the data of the protocol file (Tab. 2).

Purging

PEM fuel cells operated with hydrogen show discontinuous behaviour during their operation. Even at constant external conditions, such as temperature, quantity of the supplied air and hydrogen and their constant quality, the operation characteristics can change. These changes often cause a reduction of the electrical power output. Such effects are mostly due to the reduction of the reactive catalyst surface by accumulation of inert gas components, to inhomogeneous distribution of humidity over the whole surface of the membrane, and to inhomogeneous current density distribution.

A simple measure to reduce this effect is the so cold purging of the hydrogen-containing component of the device. For this reason the valve situated at the stack exit (H2 side), which is closed during normal operation, will be opened for a short time. A small quantity of unused hydrogen will be blown-off, but the stack can now be operated stably with distinctly higher power for a considerable time. An indicator for the necessity of purging is for example the output current of the stack at constant stack voltage (see 6.4.1).

5.2.5 Cooling phase

Independent of the reason of the end of the charging process, the cooling phase sets in after the process has stopped. For each decrease of stack temperature of 5 Kelvin the pump will be switched-on for about 1 s in order to remove condensed humidity from the stack. This phase is time-independent, and the only criterion for its end is the difference between stack temperature and ambient temperature. If this difference is lower than 2 K, the cooling phase stops. The cooling phase can be aborted by shortly pressing the red key.

5.2.6 Stand-by mode

After the cooling phase, the device is in stand-by mode. Temperature and accumulator voltage are still surveyed, and the possibility to communicate through the USB interface is maintained. The stand-by mode is signalised by the LED (Fig. 6).

5.2.7 Heating mode

If the stack temperature becomes lower than the set minimum value (e.g. in case of frost in outdoor use) the device switches into heating mode. In this mode, a part of the generated electrical power is used for charging the accumulator, and the remaining part is used for heating the relevant components. If during the heating

mode the accumulator voltage reaches the value of the final charging voltage, the whole electrical power generated by the fuel cells is used for heating.

5.3 Operation with GSM module (optional)

The optional GSM module enables the communication with the fuel cell unit through mobile network. On the one hand, the device can send system information or user-specific information (e.g. events at the user-inputs or information derived from them, respectively) by SMS and/or e-mails. On the other hand, the fuel cell unit can receive and process command sequences by SMS and/or e-mail.

5.4 Messages / signals

The fuel cell unit generates the following messages and provides them as electric signals at the connection M (messages):

Device in operation
This signal is set when the fuel cell unit is in operation and charges the accumulator. - Connection M, digital out pin 2, open collector, maximum 10 mA. - Additionally, the green LED is flashing.
Common fault
This signal is set when the accumulator voltage drops below the preset value. This can only occur in case of failure. - Connection M, digital out pin 3, open collector, maximum 10 mA
Low pressure H2 accumulator
This signal is set when the pressure in the hydrogen accumulator drops below a preset value (e.g. 20 bar). The precondition for this signal is that a manometric switch is connected with connection S (H2 accumulator), pin 8. - Connection M, digital out pin 4, open collector, maximum 10 mA - Additionally, the red LED is flashing.

Additionally to the signalling of messages by setting digital outputs of the connection M, relevant information are signalised by flashing patterns of both LED of the control panel, too.

LED green	LED red	STATUS OF DEVICE
t	t	INITIALIZATION GSM-FUNCTION
1s 1s 1s	1s 1s 1s	INITIALIZATION
0,2s 0,2s 2s		READY FOR START UP
1s 1s 2s		DEVICE CHARGES ACCUMULATOR
	0,2s 0,2s 1s	LOW PRESSURE OF H2 BOTTLE
	1s 1s 1s	FAULT H2 SUPPLY

Fig. 6: Flashing patterns of the LED

6 Description of the Visualisation and Parameterisation Software

6.1 Preliminary remarks

Together with the device, a parameterisation and monitoring software for PC is supplied. In the following, details as to function and handling of this software are given.

System requirements

Hardware:
- Customary medium performance PC with USB interface

System software:
- MS Windows (2000, XP)

6.2 Installation

The software is installed like any common Windows software:

1. Insert data carrier
2. Begin installation by running **setup.exe**
3. Follow the commands of the installation program (enter path, etc.)
    a. Installation step back by clicking on **back**
    b. Abort installation by clicking on **abort**
4. Finish installation by clicking on **finish**

6.3 Uninstall process

If the software is to be removed from the hard disk, proceed as follows:

1. Open the Windows **Start Menu**.
2. Open the **Control Panel**.
3. In the control panel, click on the **Software** symbol.
   A list of the existing programs is shown.
4. From this list, select the symbol for **FC20/FC40**.
5. Click on **Remove**. The software will now be uninstalled.

6.4 Structure of the Software

6.4.1 Basic settings

After selecting the menu item 'Window → basic device settings' the dialogue window for the basic device settings opens up. Here, all significant settings for the running operation of the device can be carried out.

	Indication *If an invalid value is entered in a data field (value outside of the permitted range for this data field), an indication appears:*	Out of Range Data Type: float Min Value: 0.0 Max Value: 17.0 Default Value: 15.0

Accumulator settings

In (7), a preselection is possible between a 12V and a 24V accumulator. If the existing setting is modified, the corresponding default voltage levels for the begin and the end of the charging processes will be set. For this, a customary lead-acid accumulator is assumed as it is commonly used as starter battery for motor vehicles.

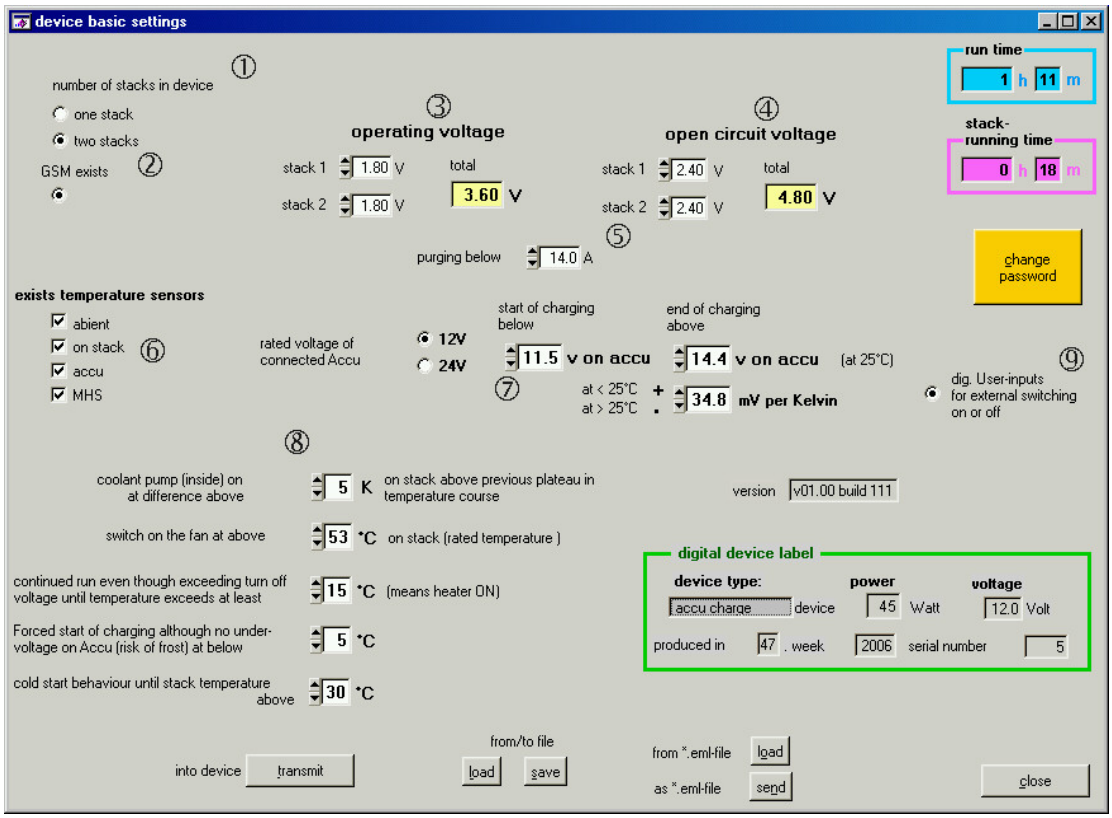

device basic settings
run time
1 h 11 m
stack-running time
0 h 18 m
number of stacks in device
one stack
two stacks
GSM exists
operating voltage
stack 1 1.80 V
stack 2 1.80 V
total 3.60 V
open circuit voltage
stack 1 2.40 V
stack 2 2.40 V
total 4.80 V
purging below 14.0 A
change password
exists temperature sensors
abient
on stack
accu
MHS
rated voltage of connected Accu
12V
24V
start of charging below
11.5 V on accu
end of charging above
14.4 V on accu (at 25°C)
at < 25°C
at > 25°C
34.8 mV per Kelvin
dig. User-inputs for external switching on or off
coolant pump (inside) on at difference above 5 K on stack above previous plateau in temperature course
version v01.00 build 111
switch on the fan at above 53 °C on stack (rated temperature)
digital device label
device type:
power
voltage
accu charge device 45 Watt 12.0 Volt
produced in 47 . week 2006 serial number 5
continued run even though exceeding turn off voltage until temperature exceeds at least 15 °C (means heater ON)
Forced start of charging although no undervoltage on Accu (risk of frost) at below 5 °C
cold start behaviour until stack temperature above 30 °C
into device transmit
from/to file
load
save
from *.eml-file load
as *.eml-file send
close

Fig. 7: Basic settings

With respect to a temperature of +25°C it can be assumed that an accumulator as shown in the example above is discharged when its voltage has dropped below 11.5 V. In the contrary, a voltage of about 14.4 V indicates that it is fully charged. If, beyond this voltage level, the charging process continues, the water in the accumulator begins to decompose in its gaseous components. If the corresponding loss of water will not be compensated, the accumulator will be permanently damaged. That means that overcharging has to be avoided. For the final charging voltage depends on the accumulator temperature, an additional parameter can be set that adapts the effective recognition of the final charging voltage according to the temperature. The correct value for the influence of the temperature on the rated val-

ues of the accumulator voltages must be taken from the manufacturer's data of the accumulator.

	Danger *If values are entered which are within the permitted range for the data field but not permitted for the accumulator (see data sheet of the accumulator) the accumulator can be destroyed, or the device can be damaged, respectively.*

Purging current

When the current drops below the purging current set in (5), the process of purging will be started. If the time between two purgings is in average about 2 minutes, optimum setting can be assumed. Longer pauses between the purgings would be of advantage, but the average output power would be lower than in case of more frequent purgings. However, if in the case of a relatively lowly set purging current the output power seems to be sufficient for the actual application, and the device is running stable for a considerable time, the lowest possible value should be chosen. This will lead not only to a minimum hydrogen consumption but also for a longer service life of the stack.

Operating voltages

In (3) the operating voltages of the stacks are set. The total value will be used by the built-in DC-DC transformer to dynamically adjust the electrical power required from the stacks so that this total voltage is always exactly reached (constant voltage operation).

As standard, a single stack as it has been used for the FC20/FC40 (consisting of three cells) is operated with 1.8 V (corresponding to 0.6 V per cell). This voltage is a good compromise between efficiency, power, operation characteristics and service life. According to the concrete stack properties, values that are slightly different of the values mentioned above can be preset or set.

If the FC20/FC40 is provided with 2 stacks, slightly different operating voltages for the stacks are possible or reasonable, respectively. The voltage stabilisation mentioned above refers to the sum of both stack voltages. For this reason it is possible that the voltages that are measured during operation, and the actual monitored voltages (for example in the diagrams or in the general chart) can differ from the rated voltage levels preset here. If the voltage difference between the two rated voltages of the stacks exceeds a critical value, purging takes place. If purging is not successful, the device will be shut down.

Open-circuit voltages

The rated open-circuit voltages to be entered in (4) are significant only for the start of a charging cycle. The comparison between the actual open-circuit voltages and

the rated open-circuit voltages before the start of the device provides a first indication for the operatability of the stacks. If the supply with hydrogen and air are ensured, the measured voltage for each stack should be 2.4 V (0.8 V per cell) or higher when no current is drained. In this case the stacks are operational, and by successively increasing the drained current, the electrical output power can be increased. The stack voltages will consequently decrease gradually. After the operating voltage is reached, this value will be kept constant.

The operating stack voltage in particular has a far-reaching influence on the operation characteristics and the service life of the stacks. In extreme cases, permanent damages can occur within short time if a too low value has been set for the voltage. Therefore, only staff with special knowledge in the field of fuel cells should be allowed to modify the settings.

Temperatures

The stacks are situated in a container with coolant. On the one hand, this coolant will cool the stacks efficiently in case of high ambient temperatures, and on the other hand, its great thermal capacity will expand the cooling phase in case of low ambient temperatures. The heat emission of the stacks to the surrounding liquid leads especially in case of a start at low temperatures to layer formation and thus to an unfavourable temperature distribution. For this reason, a pump that has been built in the container makes circulate the liquid. For reasons of energy saving, this pump is not operated continuously. In the topmost input field for the different temperature settings (8), within the range between 2 K and 10 K it can be determined for which increase of temperature (in K) the circulation pump will be switched on. In the moment of switching-on the pump, the corresponding temperature sensor will measure a temperature drop. For the stack will continue to heat the container, after a certain period of time the temperature at which the pump has been switched on will be reached again, and now the pump will be switched off. This leads to a step-by-step march of the stack temperature. The individual steps are denominated here as temperature plateaus.

The other temperature settings are described by their denominations.

Switch on / -off with external signals

There is an other option as switch on and –off the fuel cell unit depended on the voltage by the accumulator. This is an option for external switching with separate ports.

Is the Dot at (9) in the basic setting are set, the fuel cell unit switches on when a ‘1’-Level is detected at the digital-user input number one. To dedect this happening safely, the level must be active at least for 0.2 seconds. Before the inverted

happening can be dedected, the active Level have to take back (use the digital-userinput number two in the same way to switch off).

> *Hint*
>
> *Speciation settings for the digital-userinputs by using GSM-functions must be deactivated.*
>
> *Be carful that at the digital user-inputs never have an active level at the same time.*

Loading / saving the set of parameters

The set of parameters actually shown can be transferred by the "transmit" button in the menu item "to device" to the FC20/FC40. By "load" and "save" in the menu item "from/to file" the actual set of parameters can be stored on the data carrier, or a stored set can be loaded from there. Furthermore, with "load" and "save" it is possible to load a set of parameters that has been sent by e-mail, or to transmit the actual set as e-mail (optional GMS module required). The procedure of loading and converting a set of parameters from an e-mail is described in 6.4.6 by **Error! Reference source not found.**.

6.4.2 Schematic overview

After selection of the menu item 'Window → schematic overview' an animated scheme will be presented. It shows the device, together with its connected components. Additionally, the graphical presentation and the corresponding captions indicate the state of the components.

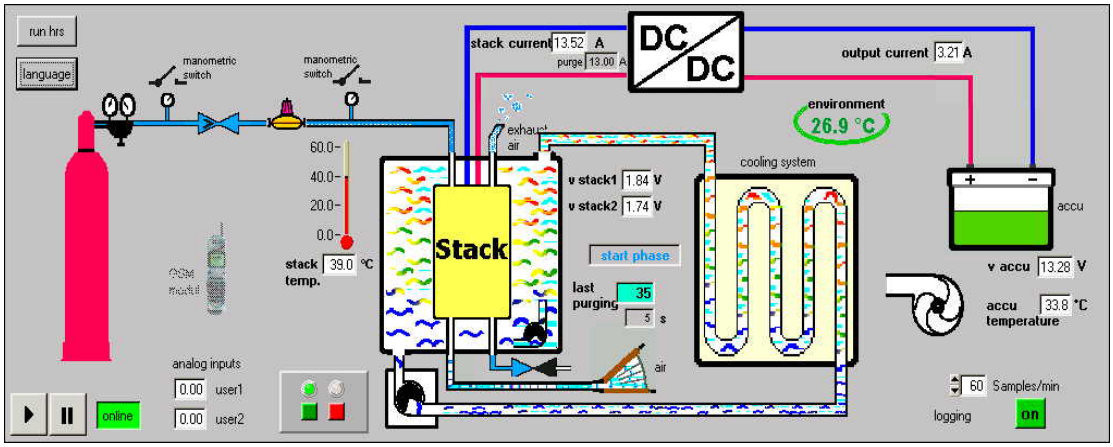


Fig. 8: Schematic overview

6.4.3 File types / file denominations

The software offers numerous possibilities for data storage. The data are stored in 4 different file types. With exception of the data stored in a special format into *kfg files all data are stored in ASCII format.

	File extension	Stored information	Attach new data	File name changeable
1	*.hst	All charging processes (table history)	no	yes
2	*.hss	Last charging process (Fields below table history)	yes	yes
3	*.kfg	Device configuration (Basic settings device)	no	yes
4	*.prt	Logging of relevant data (runs in background)	no	no

Tab. 1: Overview file types

For the automatically generated and proposed standard file names the following has been specified, independent of whether the names can be modified afterwards or not:

Example: FC040120192006002_00274_24.prt

- 00274: Current count of the operating hours meter
- 24: Serial number from digital type plate
- 2006: Year of construction
- 02: Week of construction
- 12: Nominal output voltage (here: 12.0V)
- 040: Nominal power of the device [stack(s)] (here: 45W)
- FC: Device type “Fuel Cell Unit”

6.4.4 Recorder function

After selecting the menu item ‘Tools → recorder’, the window for the graphical presentation of the measured values opens up in the lower half of the screen.

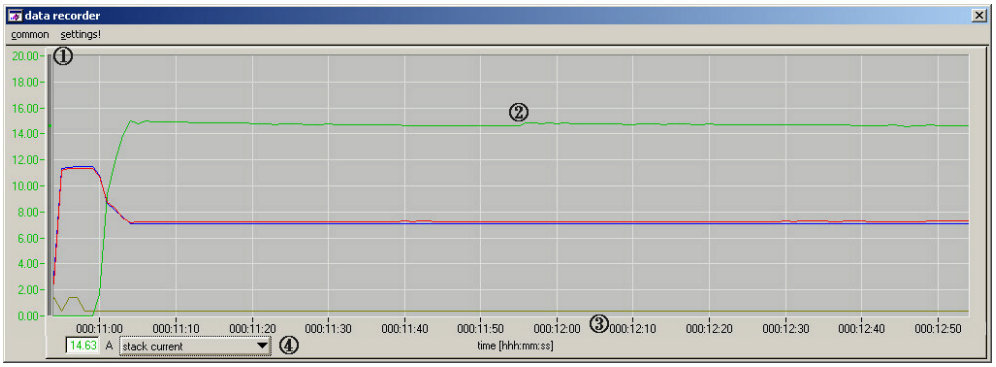


Fig. 9: Recorder window

The preset length of the timeline (3) is two minutes. After the start, the previously selected measured values are shown as coloured curves going from left to right in a unit diagram. When the right margin of the indicating range is reached, the display changes into rolling mode. Now, the oldest values are displaced outside the display on the left margin. The measured values are not stored beyond the 2 minutes during which they are displayed. This function only serves for real-time monitoring of the operation of the fuel cell unit. In order to record the measured values for rea-

son of subsequent evaluation (even for longer periods of time), the logging function must be used. The time data on the x-coordinate are continuously adapted to the actual time.

The y-axis of the diagram (1) can be changed without interrupting the display of the measured data. The easiest way to do so is to bring the curser to the respective curve and to click on it. Then, on the left margin of the display, a scale with the colour of the selected curve and with the corresponding values appears. Additionally, on the lower margin the value and the unit of the most recent measured value will be displayed (corresponding to the point of the curve in the right end of the curve). If – as it is shown in figure 9 – two curves superpose each other, the selective list (4) can be opened and the scale to be displayed can be determined explicitly.

Without further selection, in the bottom margin of the diagram a curve is displayed which does not refer to a scale. This curve only makes visible interventive measures of the controller during operation (e.g. purging, decrease or increase of air, etc.).

The menu item “settings!” opens up a window where measured values (1) to be displayed can be selected.

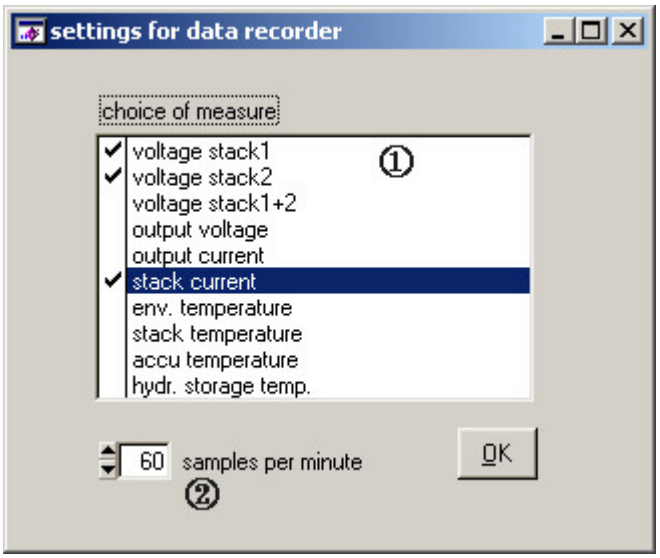


Fig. 10: Selection for display

The colours of the curve to be displayed are assigned automatically. The topmost measured value of the list selected and marked with a checkmark will be displayed in red. The following curves will be displayed in blue, green, yellow and magenta. Finally, the brightness of the mentioned colours will be changed for reasons of distinguishability.

In field (2), time resolution can be determined. The preset value is 60 samples per minute. This value can be varied between 12 (corresponding to 5 seconds for each

value) and 300 (corresponding to 5 values per second). However, only certain settings are really practicable or reasonable, respectively. In any case, the preset value of 2 minutes for the display time will remain constant, but the number of the individual measurements per unit of time that will be displayed will change.

6.4.5 Logging function

Pressing the "start" button ('logging') in the window with the schematic overview starts the logging process for all measured values and status information. Automatically, a ASCII file with the extension *.prt is generated in which the data are stored in form of a table with 28 columns. The first row of each file states the sampling frequency for the data. The columns are separated by a tab stop. Deliberately, decimal separators have not been used in order to avoid data import problems with PC programs in different language versions.

Independent of the set time period (sampling rates between 300/min and 1/min are possible), after 1 hour a new file with running numbering in the automatically generated file name is generated.

Attention

If the highest rate is selected, the file size after 1 h of recording is about 1.7 MB.

The contents of the individual columns have the following meaning:

Column	Meaning
1	**Time in 0.1s with respect to the start time** For example, the entry 36076 means that the following columns contain values that have been measured after 1h 0m 7.6s since start.
2	**Output current of the DC-DC-transformer in 0.01A** For this value it must be taken into account that it does not represent the current available for charging the accumulator, because the own consumption of the device must be subtracted from it. In case of starting at low temperatures, own consumption can mean a considerable amount because for reasons of optimising the operating conditions for the fuel cell most of the available energy will be used for heating the system.
3	**Stack current** in 0.01A This value is strongly connected with the before-mentioned output current of the transformer because its calculation within the controller implies the output voltage and the efficiency.
4	**Actual purging current** in 0.01A This column represents the stack current that has been preset for the stack current in the basic device settings, and which varies in dependence of interventive measures such as purging or short-term air decrease/increase, etc., influencing the operation of the device. During operation of the device at temperatures below the specified operating temperature, the values in this columns vary, because during this phase, this parameter is adjusted dynamically.
5	**Voltage of stack 1** in 0.01V
6	**Voltage of stack 2** in 0.01V
7	**Output voltage** - identical with voltage on accumulator – in 0.01V
8	**Voltage at analog input** 1 of the user interface in 0.01V
9	**Voltage at analog input** 2 of the user interface in 0.01V

10	for internal use
11	for internal use
12	**Temperature at purging valve** or air exit, respectively, in 0.1°C
13	**Temperature at accumulator** in 0.1°C
14	**Temperature in stack container** in 0.1°C
15	**Ambient temperature** in 0.1°C (measured in the interior of the device)
16	for internal use
17	for internal use
18	for internal use
19	**Decimal in the range 0..32767** The bits represent recognised failures or indications.
	Bit 0 – open-circuit voltage during start ('0' = reached, '1' = not reached)
	Bit 1 – start phase ('0' = successfully terminated, '1' = with failure, or manually terminated)
	Bit 2 – normal run ('0' = no failure, '1' = failure occurred)
	Bit 3 – Intervention due to drop in power e.g. purging ('0' = off, '1' = on)
	Bit 4 – cooling phase ('0' = no failure, '1' = failure occurred)
	Bit 5 – reserved
	Bit 6 + 7 – Shutdown due to 00 Final charging voltage has been reached, or manual shutdown 01 Accumulator had already been fully charged, but minimum temperature has been reached only later 10 Temperature of the device above permitted maximum (cooling failure, or ambient temperature to high) 11 Stack voltage of the device was below the permitted minimum (transformer failure, or other failure)
	Bit 8 – emergency shutdown due to action of manometric switch at too low pressure ('0' = not triggered, '1' = triggered)
	Bit 9 – device with 2 stacks has determined that the stack voltage difference was too high
	Bit 10 – either a permanent device failure, or the accumulator has been disconnected
	Bit 11 – manometric switch at MHS or at H2 cylinder has been triggered
	Bit 12 – temperature sensor at stack defective
	Bit 13 - '1' – sufficient number of correct temperature measurements has been determined
	Bit 14 - '1' – purging valve rusted in or frozen; anyway, purging without effect
	Bit 15 - '1' – Interruption due to too frequent purging
20	for internal use
21	for internal use
22	for internal use
23	for internal use
24	for internal use
25	for internal use
26	for internal use
27	for internal use
28	for internal use

*Tab. 2: Column overview of log file *.prt*

6.4.6 History charging cycles

After selecting the menu item 'window → read out history' it is possible to read out relevant data with respect to the previous charging processes from the device, to visualise and to store them.

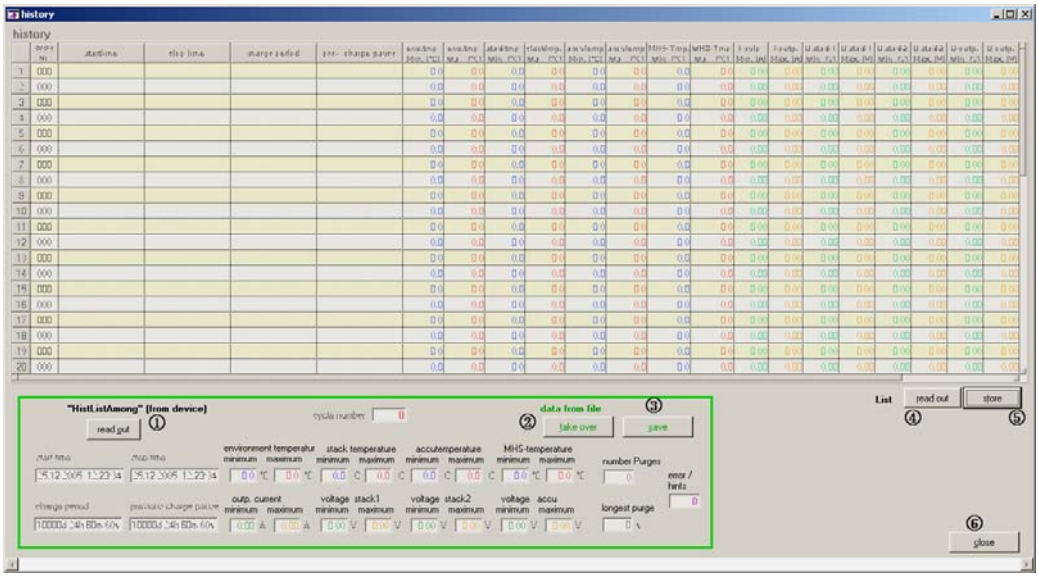


Fig. 11: History data (1)

Below the still dimmed table there is a "read out" button. If this button is clicked, the data are read line by line from the fuel cell unit and entered into the list. The maximum total number of stored charging processes is 50. After the 50th charging process, the respective oldest entry will be deleted. However, cycle numbering will continue.

history

	cycle Nr.	starttime	stop time	charge period	prev. charge pause	env.tmp. Min. [°C]	env.tmp. Max. [°C]	stacktmp. Min. [°C]	stacktmp. Max. [°C]	accutemp. Min. [°C]	accutemp. Max. [°C]	MHS-Tmp. Min. [°C]	MHS-Tm Max. [°C]
1	001	22.05.2006 11:04:22	22.05.2006 11:09:28	00000d 00h 04m 51s	00000d 00h 07m 41s	31.0	8.4	43.0	50.0	23.5	23.5	22.6	22
2	002	23.05.2006 16:48:08	23.05.2006 16:49:52	00000d 00h 01m 41s	00000d 09h 41m 16s	25.2	25.4	25.1	25.4	25.5	25.8	n.a.	n.
3	003	24.05.2006 08:45:30	24.05.2006 08:52:25	00000d 00h 06m 34s	00000d 00h 32m 21s	22.8	23.0	23.5	28.1	23.1	23.5	n.a.	n.
4	004	24.05.2006 08:59:18	24.05.2006 09:03:24	00000d 00h 03m 55s	00000d 00h 04m 48s	23.0	23.1	28.0	29.8	23.4	23.5	n.a.	n.
5	005	24.05.2006 09:06:41	24.05.2006 09:14:21	00000d 00h 07m 21s	00000d 00h 01m 54s	23.0	23.2	30.1	34.0	23.5	23.5	n.a.	n.
6	006	24.05.2006 09:17:16	24.05.2006 09:23:33	00000d 00h 06m 03s	00000d 00h 00m 53s	23.1	23.4	34.2	36.8	23.5	23.6	n.a.	n.
7	007	24.05.2006 09:25:43	24.05.2006 09:29:30	00000d 00h 03m 39s	00000d 00h 04m 11s	23.2	23.4	37.2	38.3	23.5	23.6	n.a.	n.
8	008	24.05.2006 09:35:03	24.05.2006 09:43:11	00000d 00h 07m 47s	00000d 00h 04m 07s	23.2	23.4	38.3	42.0	23.5	23.6	n.a.	n.
9	009	01.06.2006 12:58:40	01.06.2006 14:09:10	00000d 01h 07m 26s	00000d 13h 08m 01s	24.4	25.0	23.6	50.2	24.6	26.9	n.a.	n.
10	010	02.06.2006 12:17:15	02.06.2006 12:26:03	00000d 00h 00m 57s	00000d 18h 58m 07s	24.9	24.9	27.0	27.5	23.4	23.5	n.a.	n.
11	011	02.06.2006 14:31:34	02.06.2006 14:38:57	00000d 00h 07m 00s	00000d 00h 34m 16s	24.9	24.9	25.2	30.1	23.9	24.0	n.a.	n.
12	**000**					**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0**
13	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
14	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
15	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
16	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
17	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
18	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
19	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
20	000					0.0	0.0	0.0	0.0	0.0	0.0	0.0	0

Fig. 12: History data (2)

The real entries depend on the respective device equipment and configuration. When the history has been read out completely, the content of the whole table can be stored in a file for reasons of further processing or storage. For this, the button "store" (5) must be clicked.

The proposed file name can be changed at will. The preset file extension is *.hst. It cannot be modified by the user.

In order to export the data to other applications it must be considered that no special separators are used. All spaces are blank characters. For the separation of decimals, points are used (if the basic settings are not taken into account, Excel would, for example, interpret the data as dates).

After the table has been read out, possibly in the column "failure/indication" an entry in hexadecimal format can be found in which each bit position corresponds to a particular meaning. If one clicks on one of these fields with the left mouse button, the plain text form of the meaning of the entry will be displayed in the right lower area of the window.

The contents of the individual columns have the following meaning:

Column	Meaning
1	**Cycle number**, counted continuously during the entire service life of the device
2	**Start time** in real time (date and time)
3	**Stop time** in real time (date and time)
4	**Charging period** in days, hours, minutes, seconds
5	**Previous charging pause** in days, hours, minutes, seconds
6	**Ambient temperature minimum** in °C
7	**Ambient temperature maximum** in °C
8	**Stack temperature minimum** in °C
9	**Stack temperature maximum** in °C
10	**Accumulator temperature minimum** in °C
11	**Accumulator temperature maximum** in °C
12	**MHS temperature minimum** in °C ??
13	**MHS temperature maximum** in °C ??
14	**Output current minimum** in A
15	**Output current maximum** in A
16	**Stack voltage minimum at stack1** in V
17	**Stack voltage maximum at stack1** in V
18	**Stack voltage minimum at stack2** in V
19	**Stack voltage maximum at stack2** in V
20	**Accumulator** (output) **voltage minimum** in V
21	**Accumulator** (output) **voltage maximum** in V
22	**Indications** or **disturbances**, respectively, during the charging cycle
23	**Longest distance** between two **purgings** in seconds
24	**Number of purgings** during the entire charging process

*Tab. 3: Column overview history *.hst*

In the green-bordered area of the window "history" the respective last charging

process can be loaded from the memory of the fuel cell unit by clicking on the "read out" button (1). It will then be displayed in the respective fields. If an entry has been made in the field "failure/indication", its meaning will be shown in plain text form without the necessity of clicking on the corresponding field.

The (last) charging process displayed in this way can be stored to a file, too, by clicking on the button "store" (3).

Unlike the file that contains the whole table, this file has the extension *.hss, and it is a pure text file, too. For this file, too, an automatically generated file name will be proposed, unless in the popup that has been opened before, the option "attach" has been selected. In this case, an already existing file of the same type can be chosen to which the present data set will be attached. If this type of storage is used, a table whose structure is identical with that described above will be generated. This variant is particularly useful when the GSM functions will be applied (see below).

Clicking on the button "import data" allows to display values in the fields within the green frame that do not come from a connected fuel cell unit but from the content of a received e-mail. The window that opens up "open file" preferably allows the file type *.eml which is used by the e-mail program "Outlook Express" for the export of e-mails. However, other file extensions are possible, too.

When the chosen file has been opened, a window of the following type appears displaying the full content of the e-mail.

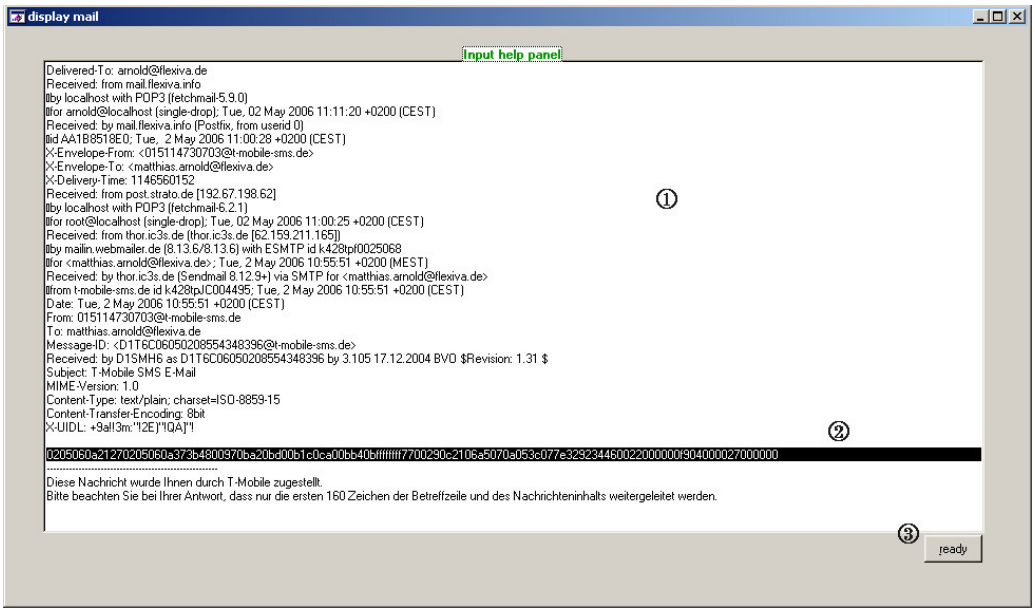


Fig. 13: E-mail import window

The concrete structure and content of such an e-mail can be very different because the numerous additional information of the e-mail header (1) are influenced by many factors. Providers, too, use to add information. For this reason the user must

mark the actual message transmitted by the fuel cell unit (2) in order to point out to the operating program the real data to be imported.

If the data are marked the button “ready” (3) is clicked, and the fields within the green frame will be filled by the data from the e-mail.

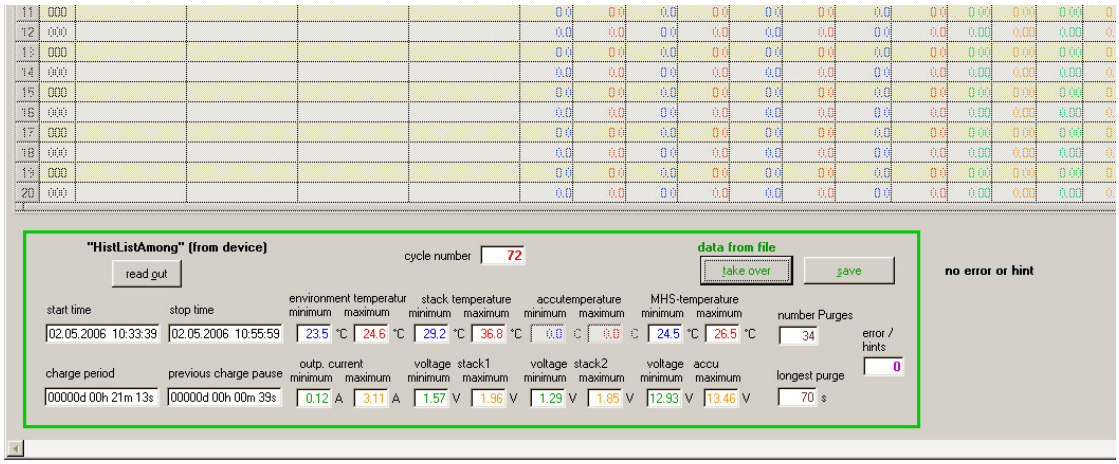


Fig. 14: History data (3)

After that, this individual data set can be stored to a file or be attached to an existing file as described above.

6.4.7 GSM module

If the fuel cell unit is equipped with a GSM module, and the corresponding entries in the basic devices settings have been made, each start of the device will begin with an initialisation procedure. During this phase, both LED will shine together for several seconds. The exact duration cannot be predicted precisely because the receiving conditions have a certain influence on it.

After a program start with correct functioning communication, the PC application will determine whether the device disposes of a GSM module or not. In case of an available GSM module, in the menu item “tools” the sub-item “GSM settings” will be activated. If this menu item is selected, the following can be seen:

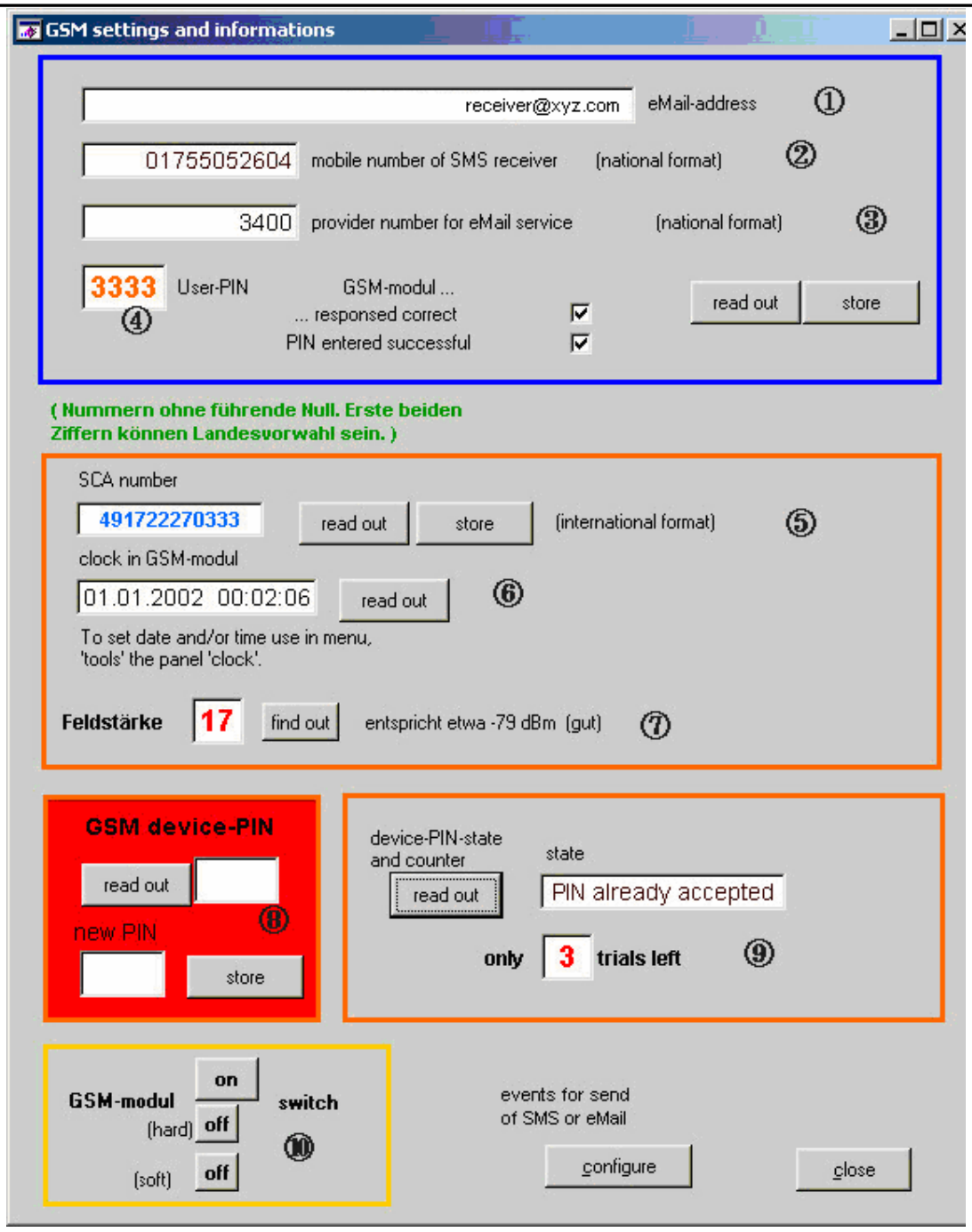


Fig. 15: Information window GSM module

The input data in the blue-bordered fields are used exclusively by the controller and therefore only stored by it; they do not require a direct connection with the GSM module (which can be switched-off at that time).

The e-mail address (1) designates the receiver of the messages, which will be sent by the fuel cell unit on request or in event-dependently. The remote communication by e-mail offers certain advantages with respect to SMS communication as to further data processing. Several mobile network providers are limiting this kind of data transmission with respect to number and/or scope. Further information on this

topic must be requested from the contractual partner of the respective network. Although it is possible that a mobile phone receives e-mails in form of SMS this option is not supported because all advantages of e-mail communication would be lost in this way. For this reason, it will be generally assumed that the sender of an e-mail from the device is a PC.

Hint

It is generally assumed that the receiver of the e-mail is a PC.

In order to receive messages of the fuel cell unit with a mobile phone, its telephone number must be entered into the next field (2). If the fuel cell unit and the receiving mobile phone are in different countries it is necessary to use the international code of the telephone number. That means that the leading zero must be replaced by the international dialling code (49 for Germany).

A message sent by the GSM module that is to be received as e-mail must be submitted to a (provider-dependent) special service number (3). The given example is "8000" for the D1 network.

The four-digit PIN (4) ensures that unauthorised or accidental transmission of a message / a command will not cause malfunction or disturbances. This PIN must not be confounded with the PIN of the GSM module inhibiting abusive use of the SIM card.

Requests, or inputs/modifications, respectively, in the orange-bordered fields require a data connection between fuel cell unit -controller and the GSM module. The window with the schematic overview of the fuel cell unit shows whether such a connection exists or not (no connection → dimmed presentation of the symbol of a mobile phone).

In the menu sub-item 'tools → clock' it is possible to determine the duration of the on- and off-conditions of the GSM module. The new settings only become effective after the present active settings have run out.

In the yellow-bordered field, a button for explicitly switching-on the GSM module can be found.

Unlike in the case of a voice communication, the data of an SMS/e-mail are first transmitted to a provider or network-dependent service number, respectively, in order to be transferred then to the real receiver. The service number for the SMS communication is stored in the mobile phone (in this case, in the GSM module). With the "read-out" button, the number stored in the GSM module (5) can be displayed (it is also possible to submit a changed number to the GSM module with the "store" button next to it).

With the "read-out" button in the field below, time and date (6) of the GSM module can be displayed. If necessary, in the window 'tools → clock' it is possible to set this clock. However, this will not influence the function or the contents of the message.

The on-site received field strength can be detected with the button "detect" in following field below (7). This function should be executed several times during the setting up of the fuel cell unit. The detected values should be commented with remarks enabling the assessment of the reception reliability (quality). In case of values below 10 it should be checked whether another installation location would provide better results. Often, small displacements can already lead to distinct improvements.

With the next field below, which has a red background (8) the PIN of the SIM of the GSM module can be read out and modified if necessary. Each time when the controller in the fuel cell unit switches on the GSM module, the PIN is requested just like in case of a mobile phone. This action is carried out in the background by the controller, and the PIN stored in its EPROM is used for it. Only when this PIN is the same as it has been stored in the SIM card of the GSM module the log-on takes place, and the device becomes ready to send and to receive. In order to change the PIN, in any case the "read out" button must be clicked before. A change will only be successful when the PIN read out (from the controller) is correct for the connected GSM module.

If the SIM card in the GSM module is replaced, or a wrong PIN has been entered it is possible that the controller tries to start the GSM module with an incorrect PIN. After three erroneous PIN requests in the field "state" the message "PUK expected" appears (9). In this case the SIM card must be removed from the GSM module and inserted into a mobile phone. After switching on the mobile phone, the PUK will be requested, too. This eight-digit number required now can be found in the documents handed over to the client with purchase of a SIM card (or with contract conclusion, respectively).

The yellow-bordered area (10) serves for explicitly switching on or off the GSM module by the controller of the fuel cell unit. Preferably, for switching-off, the "soft" method should be used. In this way, the GSM module receives a command for "shutdown" and for automatic switching-off. So it will be ensured that the modifications made will be stored in the GSM module. If due to communication disturbances or other malfunctions this method is not applicable the only way out is the "hard" switching-off. In this case, the power supply of the GSM module will be interrupted.

Clicking on the "configure" button opens up the following window:

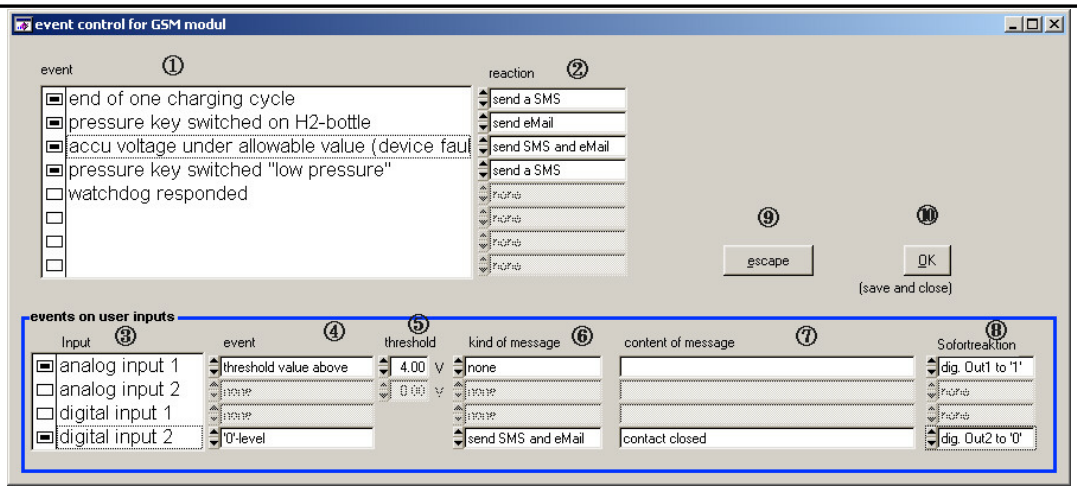


Fig. 16: Event control for GSM module

In case of certain events the fuel cell unit offers the opportunity to submit a respective message to the user. For each individual event that can be activated in the menu (1) it can be additionally determined whether it has to be transmitted by SMS to a mobile phone, or by e-mail to a PC (or both) (2).

If for example the first entry in the menu is activated ("end of a charging cycle"), a message in the following form will be submitted to the respective receiver as soon as the charging process is finished. Each individual (sedecimal) number within a message corresponds to certain measured values or states that have been detected during the charging cycle. The procedure to convert this rather cryptic message in plain text is the same as described under 'History charging cycles'.

From: 015114730703@t-mobile-sms.de
To: receiver@xyz.com

18050609111018050609172106009 30b950b020c1c0c970b980bfffffff42080509ff06ad07ac05af06fe33a7364400070000006b01000035000000

This message has been submitted to you by T-Mobile.
Please consider for your answer that only the first 160 signs of the subject line and of the content of the message will be transmitted.

If the hydrogen accumulator (cylinder) is equipped with a manometric switch and the second entry of the menu is activated, the receiver will receive a message with the following content in the case that the manometric switch has been triggered:

From: 015114730703@t-mobile-sms.de
To: receiver@xyz.com

Manometric switch on H2 cylinder has been triggered

This message has been submitted to you by T-Mobile.
Please consider for your answer that only the first 160 signs of the subject line and of the content of the message will be transmitted.

In dependence of the set value of the manometric switch it can be determined how long the hydrogen supply can still be maintained, and when the gas cylinder has to be replaced by a full one at the latest.

When the voltage of the connected accumulator falls below the voltage level of the basic device settings, the fuel cell unit automatically starts the stacks and the charging process. That means that in case of a correct function the voltage level can never be significantly lower than the set threshold value. If this case occurs nevertheless it indicates a failure, which can probably not be remedied without repair. The corresponding message is as follows:

From: 015114730703@t-mobile-sms.de
To: receiver@xyz.com

Accumulator voltage has dropped below critical value!

This message has been submitted to you by T-Mobile.
Please consider for your answer that only the first 160 signs of the subject line and of the content of the message will be transmitted.

The fuel cell unit disposes of a built-in manometric switch fulfilling an important safety function. If the hydrogen supply will not be replaced in time or if there is a significant leakage in the system there is a risk that the stacks would be damaged due to undersupply. Operation with insufficient hydrogen supply must be absolutely avoided. The built-in manometric switch is triggered at a pressure that usually is sufficiently above the risk zone for the stacks. If the device recognises the triggering of this switch during operation, immediately load-disconnection and shutdown take place. If the corresponding entry in the menu (1) has been activated, the device sends the following message:

From: 015114730703@t-mobile-sms.de
To: receiver@xyz.com

Manometric switch 'low pressure' has been triggered

This message has been submitted to you by T-Mobile.
Please consider for your answer that only the first 160 signs of the subject line and of the content of the message will be transmitted.

Hint

If the above messages are sent by SMS to a mobile phone only the parts of the example messages with yellow background will be displayed.

The blue-bordered area offers convenient and flexible possibilities for the user of

the FC20/FC40 to install remote control and survey functions corresponding to his concrete problem, reaching well beyond the normal functions of a fuel cell unit.

In the first selection box (3) the object to be surveyed can be determined. Depending on whether a digital or an analog input has been chosen, a corresponding event can be selected now (4). In case of an analog input (on which a voltage between 0 V and 10 V can be applied) this event can be that the voltage falls below or exceeds a voltage level defined in the next input field (5). For the first digital inputs, the corresponding event can be the detection of a "0" level or "1" level. Since these inputs are evaluated with the polling procedure, in the least favourable case a duration of 125 ms is required for the detection of the significant level.

Each previously defined event can be defined in the next selection field as condition for the submittal of a message. As already described for the system events, it can be chosen between SMS, e-mail or both communication ways (6). If the choice has been made to send a message in case of the next occurrence of the respective event the content of the message can be formulated at will, and be entered into the following input field (7).

Independent of whether a message has to be transmitted or not, the states of the two available digital outputs can be event-dependently influenced. By respective selection in the last field (8) the digital output 1 or 2 can be set to "0" level or to "1" level in case of the occurrence of the related event. A possible variant is the logical negation of the actual state.

By clicking the "OK" button (10) the chosen settings are transferred to the controller of the fuel cell unit. If the transfer is not desired the window can be closed by clicking on the "abort" button (9).

For all events on the user-inputs the following applies:

If an event to be monitored by the controller did occur, the corresponding reactions will be carried out only once. Therefore it is insignificant how long the event continues. But it also means that the new occurrence of the significant event (even after the previous event-relevant state has already ended) does not lead to a new reaction. In order to "arm" the event control anew, a special message must be sent to the fuel cell unit or its GSM module, respectively (explanations in the respective paragraph).

Hint

Reactions to USER events are carried out only once. The event control must be reset explicitly by sending a special message.

The FC20/FC40 is not only capable to send messages but also to receive messages and to react in the way described in the following. The special content of the SMS or e-mail to be sent to the fuel cell unit has been summarised in a table:

Content of the SMS or e-mail	Action of the receiving fuel cell unit
7 xxxx yyyy	Change user PIN (xxxx – old valid PIN; yyyy – new PIN)
10 xxxx	Reset the event control on the user-inputs. (Condition for a new recognition of an event)
11 xxxx	Set digital user-output 1 to "0"
12 xxxx	Set digital user-output 1 to "1"
13 xxxx	Negate digital user-output 1
14 xxxx	Set digital user-output 2 to "0"
15 xxxx	Set digital user-output 2 to "1"
16 xxxx	Negate digital user-output 2
18 xxxx	The logged data of the last executed or of the present charging process will be sent by SMS to the mobile phone designated in the fuel cell unit
19 xxxx	The logged data of the last executed or of the present charging process will be sent by e-mail to the e-mail address designated in the fuel cell unit.
	The format of the message in case of commands 18 and 19 corresponds to that which is used in the comparable system event.
48xxxx	The basic device settings will be send by SMS to the mobile phone designated in the fuel cell unit.
49xxxx	The basic device settings will be send by e-mail to the e-mail address designated in the fuel cell unit.

Similar to the logging data for a charging cycle, commands 48 and 49 provide sedecimal numbers, which cannot be understood by simply regarding them. Like in the case of the charging cycle messages, the operating software of the fuel cell unit offers the opportunity to convert these numbers in plain text format. For this purpose, in the corresponding fields of the basic settings window, the necessary changes must be carried out.

6.4.8 Real-time clock

If the menu item 'tools → clock' is selected, the following window opens up (if no modifications are entered, the window closes automatically after 2 minutes):

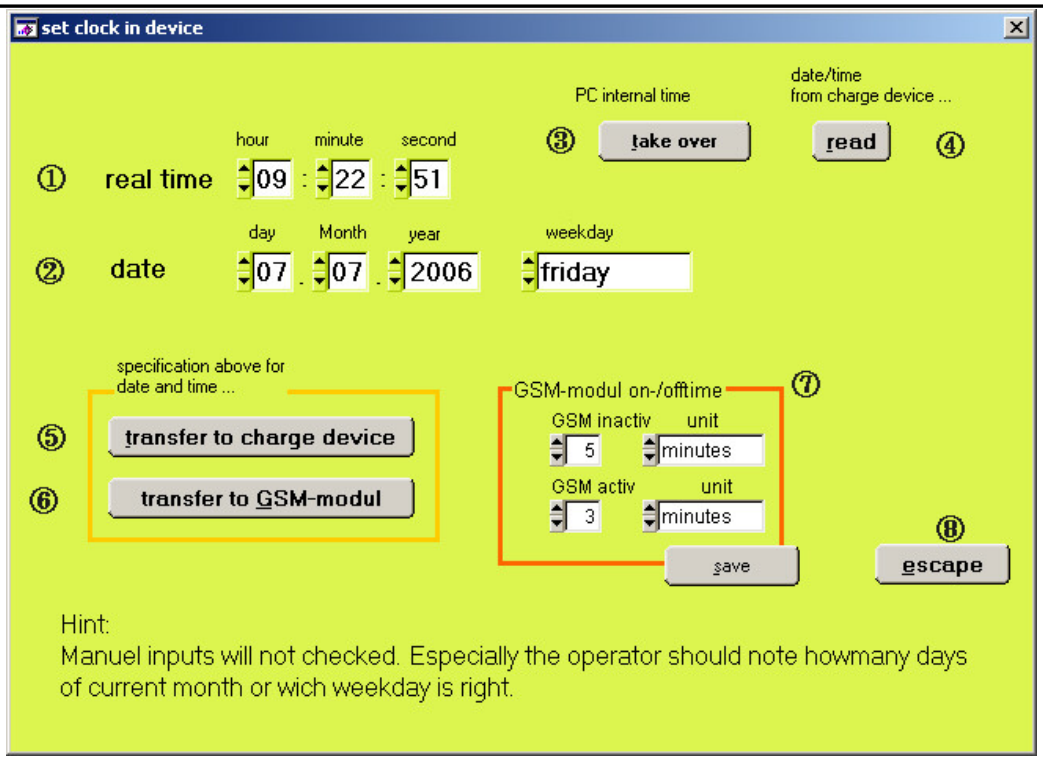


Fig. 17: Configuration real-time clock

The fuel cell unit is equipped with a battery-buffered real-time clock, which is read out when the window shown above is opened. In the fields for time (1) and date (2) the actual time and date of the fuel cell unit are shown, provided that a FC20/FC40 is connected and that the communication functions.

In order to set the clock there are several possibilities. With the small arrows in the left margin of each field the value can be changed in both directions.

Hint

Impossible entries such as the 13th month or the 25th hour will be refused for this method of setting the clock. However, the date will not be checked with respect to calendrical rules.

The easiest and safest way to set the fuel cell unit clock is to click on the "import" button (3). So, the system time of the computer will be displayed in the input fields. When the button "transfer to fuel cell unit" (5) is clicked, all values displayed in the time and date fields will be transferred to the fuel cell unit and stored there.

In order to determine whether the setting process has been successfully carried out the button "read" (4) can be used. If it is clicked, time and date of the fuel cell unit are requested and displayed anew.

The elements (6) and (7) appear on opening the window only in the case that the operating program has detected that the fuel cell unit is equipped with a GSM mod-

ule. The GSM module contains (like any other mobile phone) a real-time clock. If the fuel cell unit is disconnected from the accumulator for a longer period of time, the GSM module loses the correct time and date values. With the button "transfer to GSM module" this clock can be set, too, with the values displayed in the input fields.

Hint

The content of the GSM module clock is insignificant of the functions and for the contents of the messages.

The orange-bordered fields serve for the preset of on- and off-times of the GSM module. The controller in the fuel cell unit switches the GSM module on and off according to the values entered here. If the GSM module is to be switched-on continuously, in the field "unit" for "inactive time" the option "none" must be selected (in the opposite case the procedure is analogous). If for both times (inactive and active) in the field "unit" the option "none" is used, the inactivity of the GSM module is prioritary; the module remains permanently switched-off.

With the "abort" button (8) the window can be closed.

7 Maintenance Service and Repair by the Customer Service

According to the general sales terms and conditions for the device supplied by the manufacturer, a GUARANTEE is issued. If during the guarantee period malfunctions or damages to the devise should occur for which according to the guarantee conditions a guarantee has been issued, the manufacturer will after previous examination repair or replace the faulty components.

The manufacturer is responsible for the device in its original configuration.

All interventions concerning the device, its structure, the software or the operating cycle of the device shall only be carried out by the manufacturer or by his express authorisation.

Attention

The stipulated environmental conditions must be kept to.

The manufacturer is not liable for damages due to improper or inappropriate use of the device and for damages due to interventions in the device that are not requested explicitly by the present manual.

For all these reasons, our customers should always contact our customer service.